INDOOR AIR QUALITY ASSESSMENT

Triton Regional Senior/Middle School
112 Elm Street
Byfield, Newbury, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
July, 2002

Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Triton Middle/Senior School, Byfield, Newbury, MA. Symptoms suspected of being related to building renovations/construction prompted the request. School department officials informed BEHA staff that construction/renovations had been completed prior to the 2001-2002 academic school year. Thus there were no renovation projects involving construction equipment, demolition or building structure additions in progress during the assessment. Only minor "punch-list" items (e.g., wiring) were remaining from the renovations.

The school was visited by Michael Feeney, Director of the Emergency Response/Indoor Air Quality Program (ER/IAQ), BEHA, on February 12, 2002 to conduct an indoor air quality assessment. Accompanying Mr. Feeney were Cory Holmes, Environmental Analyst of the ER/IAQ Program, BEHA, Chris Walsh, Manager of Facilities-Grounds for the Triton Regional School Department and Steve Orme, Head Custodian.

The school is a multi-level brick building originally constructed in 1971. An addition was recently completed and the interior of the original building was completely renovated in 2000-2001, which included an upgrade of mechanical ventilation components. The upper level of the school contains general classrooms. The middle level consists of the gymnasium, auditiorium, general classrooms, art rooms, photography rooms, administrative offices and science rooms. The lower level contains general classrooms, computer labs, science classrooms, shop areas and the media center.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school houses both middle and high school students grades 7-12. It has a student population of approximately 1,400 and a staff of approximately 100. Tests were taken during normal operations at the school and results appear in Tables 1-5.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in eleven of forty-three areas surveyed, indicating adequate ventilation in most areas of the school. Fresh air in classrooms is supplied by a unit ventilator (univent) system. Classrooms in the new addition are equipped with a dual univent system (see Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (see Pictures 2a & 2b) and return air through an air intake located at the base of each unit (see Figure 1). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. A univent was found deactivated in classroom M-230. The univent was reactivated and it appeared to be operating correctly. Obstructions to airflow, such as books, papers, and desks were seen in a number of classrooms (see Picture 1), as well as items in front of univent return vents (see Picture 3). In order for univents to provide fresh air as designed, they must be unblocked and remain free of obstructions. Importantly, these units must be activated and allowed to operate.

The mechanical exhaust ventilation system consists of ceiling and wall-mounted exhaust vents (see Picture 4). These vents were operating throughout the building with the exception of classroom M-312. Little or no draw of air was detected in this classroom (see Tables), which can indicate that either the exhaust ventilation was turned off, or that the rooftop motor was not functioning. The location of some exhaust vents can also limit exhaust efficiency when the classroom hallway door is open (see Picture 5). When a classroom door is open, exhaust vents will tend to draw air from both the hallway and the classroom. The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from classrooms. The exhaust vents in the library are located behind heating pipes (see Picture 6). This blockage can reduce the draw of air to these vents by fifty percent. Without removal by the exhaust ventilation, normally occurring environmental pollutants can build up and lead to indoor air complaints.

Ventilation for interior rooms throughout the building is provided by rooftop air handling units (AHUs). Fresh air is distributed via ceiling-mounted air diffusers. Return air is ducted back to the unit by ceiling or wall-mounted exhaust vents. Most of the AHUs were operating during the assessment. No airflow was detected from vents in classrooms H-218 and H-220, which can indicate that either the AHU ventilation was deactivated or that the unit was not functioning. At the time of the BEHA assessment, school maintenance staff stated that the heating, ventilation and air-conditioning (HVAC) equipment was still under warranty. In addition, the school department was in the process of developing a service contract with an HVAC engineering firm to establish a preventive maintenance plan.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was reportedly conducted upon completion of renovations in 2001. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million part of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, consult Appendix I.

Temperature measurements ranged from 64° F to 77° F, which were within or slightly below the BEHA recommended comfort range in most areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. A number of temperature control complaints were expressed to BEHA staff (see Tables). In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Concerns regarding excessive heat were brought up by occupants in a number of computer rooms. One of the computer rooms is reportedly equipped with air conditioning; the remaining computer rooms are not. Computer equipment and printers can generate excess heat while they operate, particularly if used frequently. Without additional temperature control/ventilation, waste heat can build up resulting in increased discomfort and potential indoor air quality complaints.

The relative humidity measured in the building ranged from 16 to 27 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Of note is that relative humidity measured indoors in most areas exceeded outdoor measurements (range +1-10 percent). The increase in relative humidity can indicate that the exhaust system is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration). Moisture removal is important since the sensation of heat conditions increases as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperatures rise, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, the comfort of the individuals is increased. While temperature is mainly a comfort issue, relative humidity in excess of 70 percent can provide an environment for mold and fungal growth (ASHRAE, 1989). During periods of high relative humidity (late spring/summer months), windows and exterior doors should be closed to keep moisture out; in addition, AHUs, univents and exhaust ventilation should be activated to control moist air in the building.

Microbial/Moisture Concerns

Spaces were noted between countertops and sinks in science classrooms (see Picture 7). Water-damaged flooring was seen below the sink in classroom H119 (see Pictures 8 & 9). School officials reported that the plumbing/sink in the classroom were installed in a manner that creates a seam that disconnects the sink from the counter. Inadequate drainage or overflow could lead to water penetration of countertop wood and potential damage to the cabinet, as well as to stored materials located therein. If wooden cabinets and porous materials become wet repeatedly, they can provide a medium for microbial growth.

Classroom H-108 contained a parrot and others contained rabbits. The rabbit cages, birdcage and the surrounding countertop areas were littered with bird wastes and/or wood shavings (see Picture 10). Porous materials (i.e., wood shavings) can absorb animal wastes and can be a reservoir for mold and bacterial growth. Animal dander, feathers and wastes can all be sources of respiratory irritants. Animal cages and surrounding areas should be cleaned regularly to avoid the aerosolization of allergenic materials and/or odors.

Shrubbery in direct contact with the exterior wall brick was noted in several areas around the building (see Picture 11). Shrubbery can serve as possible sources of water impingement on the exterior curtain wall due to the location of plants growing directly against the building. Plants retain water and in some cases can work their way into mortar and brickwork causing cracks and fissures, which may subsequently lead to water penetration and possible mold growth.

Other Concerns

A number of other conditions that can potentially affect indoor air quality were also observed. The dark room contains a local exhaust ventilation system. A ceiling-mounted exhaust vent for the school's general ventilation system is located on the opposite end of the photo-developing sink (see Picture 12). This placement will tend to draw off-gassing chemicals (against the flow of the local exhaust system) generated during film developing, which can increase exposure to volatile organic compounds (VOCs) (see Figure 2).

The storage of chemicals in the science area poses a number of potential indoor air quality and safety hazards. The cabinet that contains chemistry materials appears to be a flameproof cabinet that is connected by a duct to a non-motorized exhaust vent on the roof (see Picture 13). Without a motorized roof vent, this duct can backdraft, resulting in the off-gassing chemicals of stored containers being forced through the cabinet doors. Door fasteners have begun to corrode from such exposure (see Picture 14). A number of flammables and VOC containing chemicals (e.g., acetone, cyclohexane, t-butanol, toluene) are stored in this cabinet. Exposure to chemical vapors can be irritating to the eyes, nose and respiratory system. In addition, flammable materials should be stored in a cabinet that meets the requirements of the National Fire Prevention Association (NFPA) (NFPA, 1996). The NFPA does not require venting in flammable storage cabinets, however, if venting is done, it must be vented directly outdoors and in a manner not to compromise the specific performance of the cabinet (NFPA, 1996). In this configuration, it would not be expected that this cabinet would perform to prevent the spread of fire to stored chemicals.

Acids were stored in a cabinet beneath the chemical hood. Plumbing pipes also exist in this cabinet. Acid containers are prone to leaking and should be stored in a cabinet constructed of acid resistant materials. Pipes made of copper and steel are prone to corrosion when exposed to strong acidic materials, which may result in degradation of plumbing and lead to water leaks.

A noticeable odor of wood dust was detected in the hallway outside the door to the wood shop. Spaces were noted at the bottom and between hallway doors, which can allow for saw dust and other pollutants to migrate from the shop to the hallway. The shop does not have a ducted collection system for dust generating machinery (e.g. saws, sanders, etc.). It appears that wood particles are filtered through a wall-mounted filtration unit. It is recommended that wood dust be removed from the environment at the point of generation using a dust collection system to prevent dust aerosolization. This configuration will enhance the aerosolization of sawdust when the filter is activated, since air is drawn to the filter. Another disadvantage of this system is the need to frequently change the filter. Once a filter becomes saturated with debris, materials can pass through the filter and become aerosolized. Wood dust can be irritating to the eyes, nose, throat and respiratory system.

A number of classrooms contained upholstered furniture. If relative humidity levels increase above 60 percent, dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, M.A., 1994). It is also recommended that upholstered furniture (if present in schools), be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000).

An unvented clothes dryer was observed in the consumer science room (see Picture 15). In this condition, both moisture and waste heat from the dryer are vented into this room. The combination of water vapor and collected lint can lead to microbial growth. Dryers should be vented to the outside of the building.

Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made to improve general indoor air quality:

1. Examine rooftop exhaust motors and AHUs detailed in the ventilation section of this report for proper function. Repair/replace belts and parts as necessary.
2. Continue working with current HVAC contractor to troubleshoot problems and develop a preventive maintenance plan.
3. Remove all obstructions from univent air diffusers and return vents to facilitate airflow.
4. Install weather stripping around the door frame and door sweeps at the bottom of and between wood shop hallway doors to serve as a barrier. Consider installing a wood dust collection system to remove aerosolized wood dust from the wood shop environment.
5. Faculty and staff are encouraged to report any complaints concerning temperature control/preventive maintenance issues to the facilities department in the form of a work order. These work orders are reportedly provided by the school maintenance staff and/or administration.

6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.
8. Seal around sinks in science areas. Repair any existing plumbing leaks and replace any remaining water-damaged building materials. Examine around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial as needed.
9. Clean and maintain animal cages to prevent bacterial/mold growth and/or odors.
10. Evaluate science chemical flow hoods in order to determine proper function to contain vapors in accordance with ANSI/ASHRAE 110-1995 section 6.
11. Consider sealing general exhaust vent in darkroom.
12. Reduce/trim or remove plants that are growing against the exterior brick curtain wall.
13. Reconnect dryer hose to vent and duct to outside of the building.
14. Remove acids from cabinet underneath the chemical hood to prevent degradation of plumbing pipes.

15. Consider obtaining a flammables storage cabinet for storing flammable materials in the chemistry storeroom. Seal the vent to the existing cabinet to prevent backdraft of cold outdoor air into the building via this route.

References

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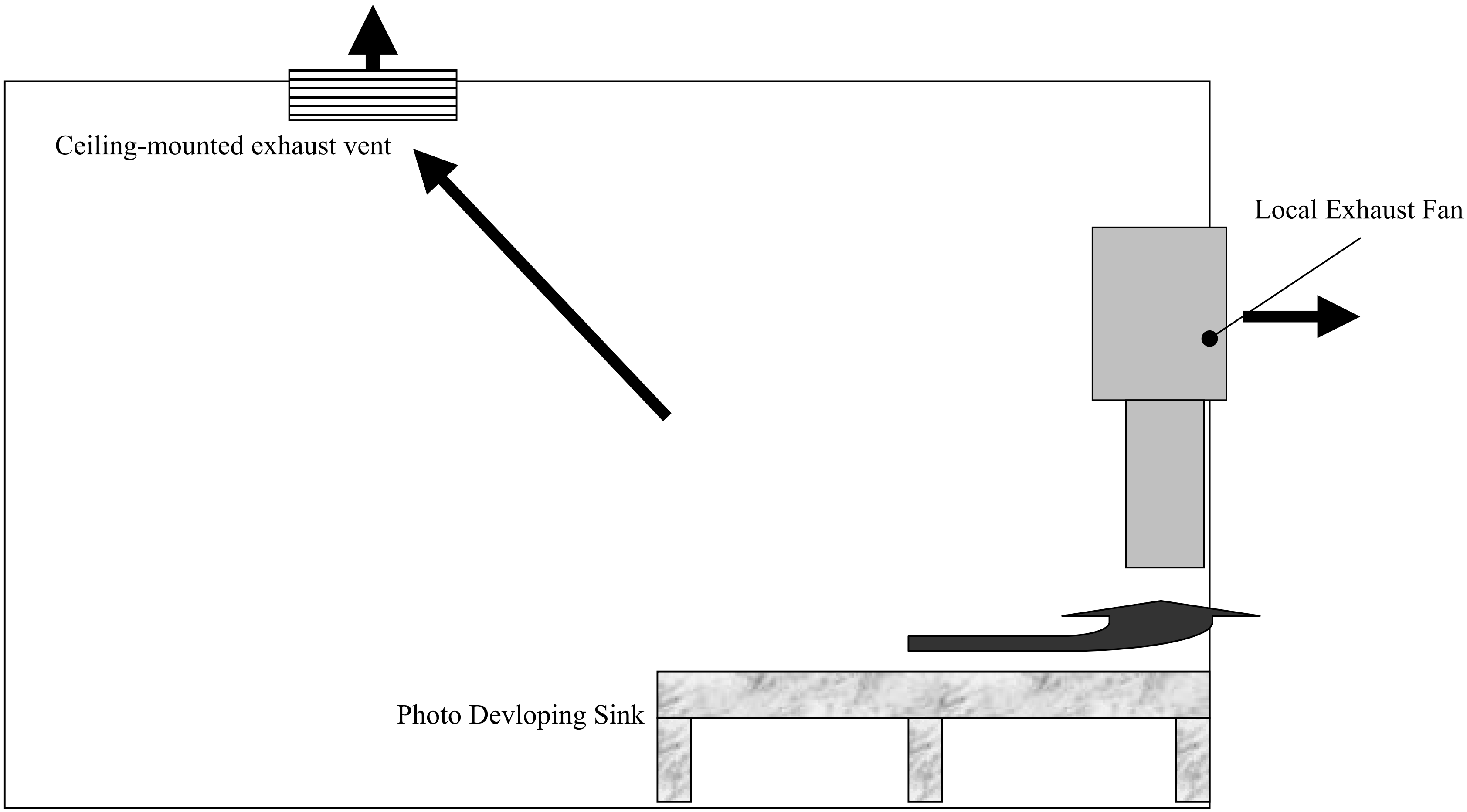
US EPA. 1992. Indoor Biological Pollutants. US Environmental Protection Agency, Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Research Triangle Park, NC. ECAO-R-0315. January 1992.

Figure 2
Photo Developing Sink and Ceiling-Mounted Exhaust Vent for the General HVAC System



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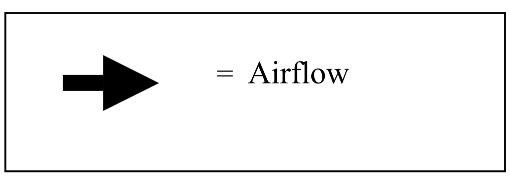


Picture 1

Dual Univent System, Note Materials Stored On Top Of Univent Air Diffusers Obstructing Airflow

Picture 2a

Univent Fresh Air Intake

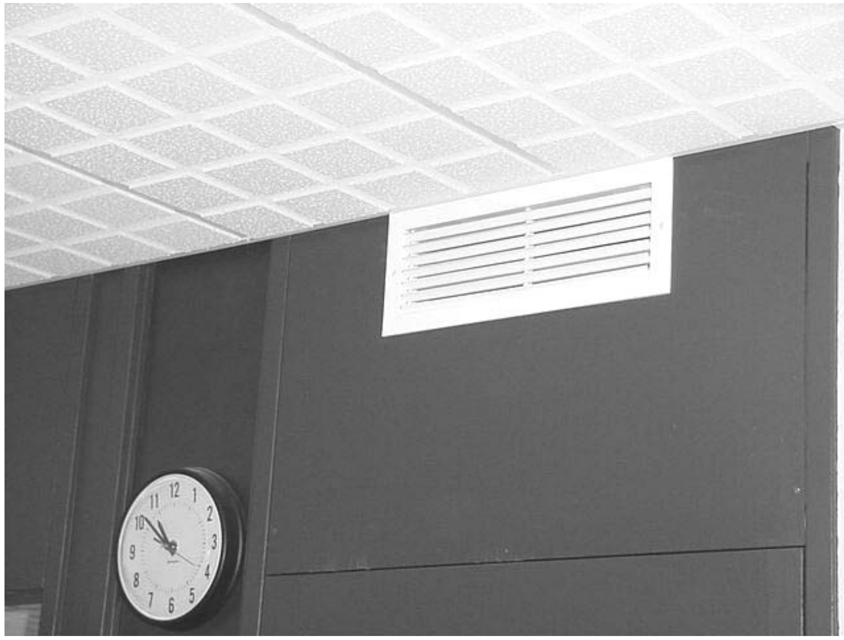
Picture 2b

Univent Fresh Air Intake

Picture 3

Sofa Obstructing Univent Return Vent (Along Front of Unit)

Picture 4



Wall-Mounted Exhaust Vent

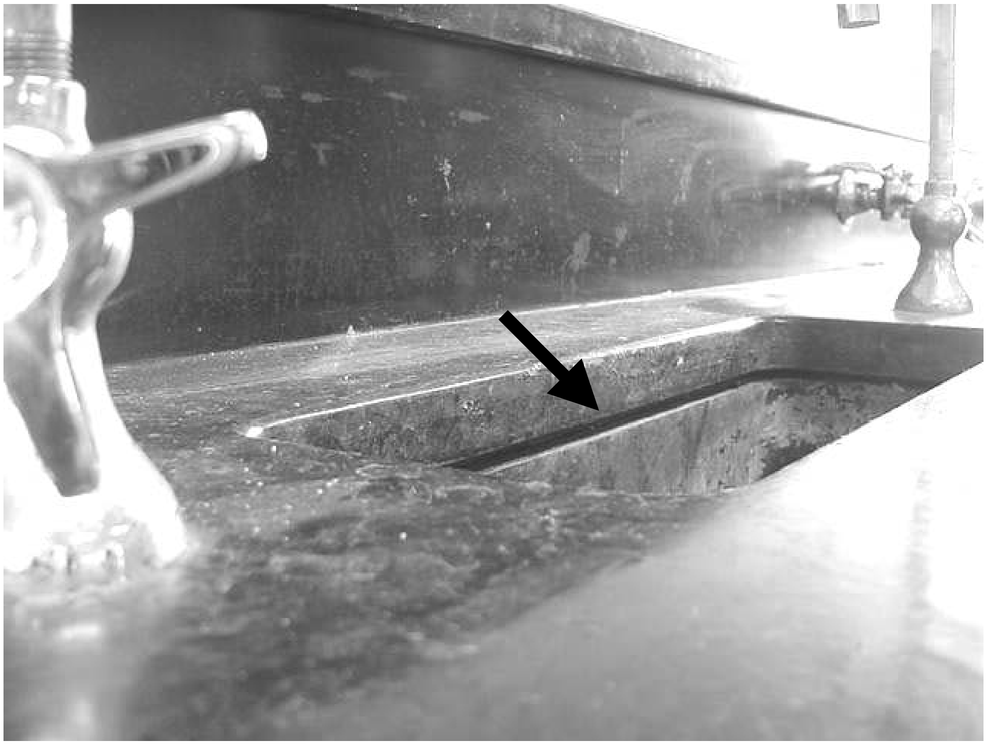
Picture 5

Ceiling-Mounted Exhaust Vent and Open Classroom/Hallway Door

Picture 6

Library Exhaust Vent Obstructed By Pipe

Picture 7



Space Between Sink and Countertop in Science Classroom

Picture 8

Water Damaged Flooring beneath Sink

Picture 9

Close-Up Of Water Damaged Floor In Previous Picture

Picture 10

Parrot and Birdcage in Classroom H-108, Note Materials on Surrounding Countertop

Picture 11

Shrubbery In Contact With Exterior Wall

Picture 12

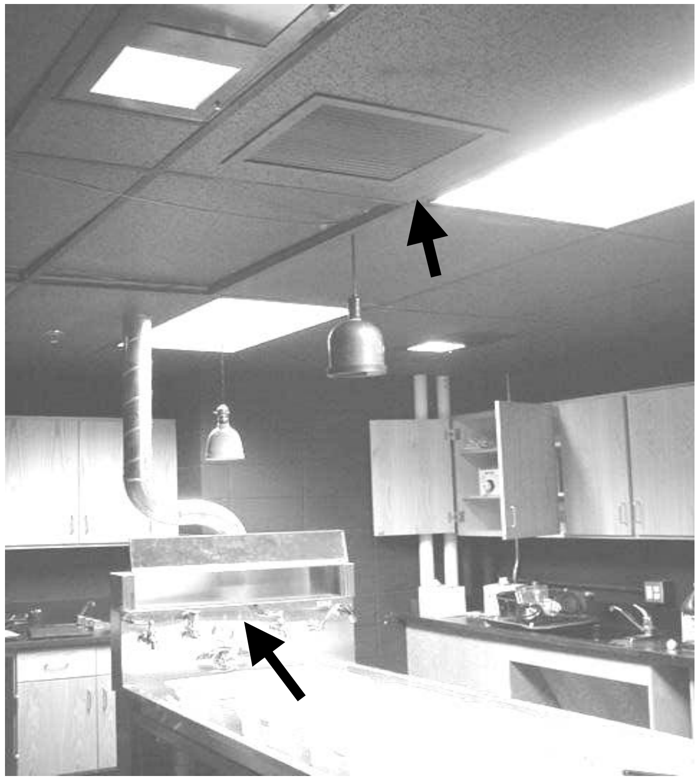
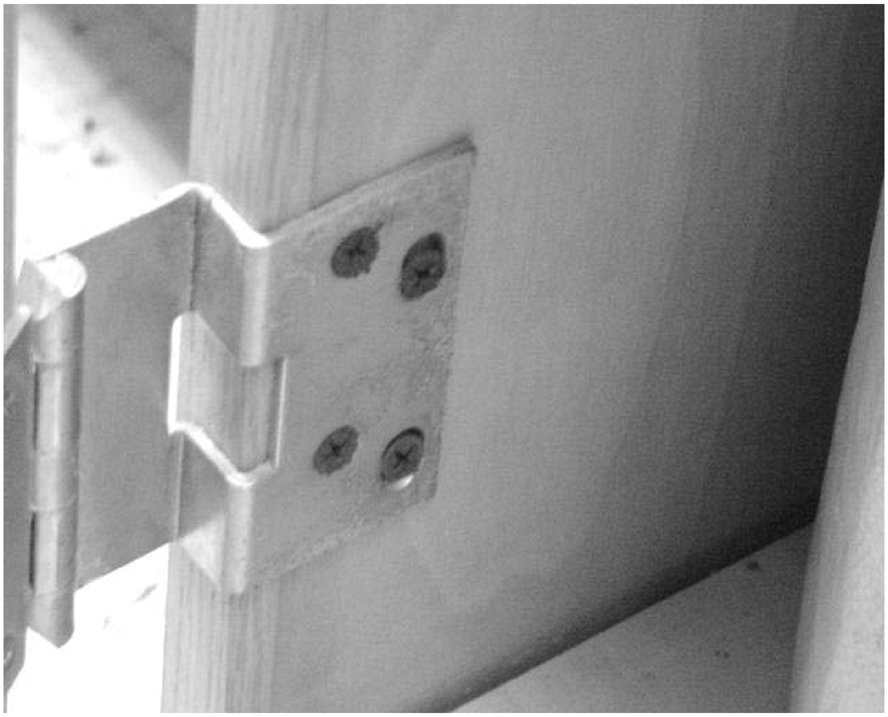


Photo Developing Sink Note Local Exhaust System And Ceiling-Mounted Exhaust Vent

Picture 13

Chemical Storage Cabinet, Note Vent

Picture 14



Corroded Fasteners On Chemical Storage Cabinet Door Hinge

Picture 15

Unvented Clothes Dryer

TABLE 1

Indoor Air Test Results – Triton Regional Middle/High School, Newbury, MA – February 12, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	354	49	17					
M230	467	64	19	0	Yes	Yes	Yes	Univent deactivated-unit reactivated by school staff, 1 water-damaged CT
M301	856	70	21	29	Yes	Yes	Yes	2 univents, door open
M300	666	72	19	19	Yes	Yes	Yes	1 water-damaged CT, items on univent, door open
M315	456	71	16	6	Yes	Yes	Yes	No air conditioning, 21 computers
M317	712	70	17	13	Yes	Yes	Yes	
M316	794	72	19	20	Yes	Yes	Yes	Door open
M325	779	71	18	16	Yes	Yes	Yes	
Boy's Restroom					No	Yes	Yes	
M227	790	75	18	1	Yes	Yes	Yes	20 occupants gone ~10 mins.

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Triton Regional Middle/High School, Newbury, MA – February 12, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
M222	619	74	16	2	Yes	Yes	Yes	
M217	620	72	18	3	Yes	Yes	Yes	
M208	515	70	16	10	Yes	Yes	Yes	24+ computers, door open, temperature complaints-cold
M203	431	70	16	1	Yes	Yes	Yes	22 occupants gone ~25 mins., door open
M100 (Tech. Ed.)	64	71	18	21	Yes	Yes	Yes	
M103	712	77	20	20	Yes	Yes	Yes	Temperature complaints-heat, door open
M105 (Consumer Science)	457	74	16	1	Yes	Yes	Yes	Dryer not vented, door open
M310 (Art Room)	954	73	21	26	Yes	Yes	Yes	Items on univent, 1 out of 2 univents on, hood over kiln
M312	419	71	16	0	Yes	Yes	Yes	No draw from exhaust vent
Art Room 201	686	70	19	17	Yes	Yes	Yes	
A202	791	71	19	13	Yes	Yes	Yes	

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Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Triton Regional Middle/High School, Newbury, MA – February 12, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Dark Room	718	69	20	0	No	No	Yes	Chemical exposure concerns, ceiling-general exhaust/table exhaust, passive door vent
H261	800	72	21	18	Yes	Yes	Yes	Door open
H206	740	67	19	1	No	Yes	Yes	Occupants gone 20 mins.
H217 (Computer Room)	989	71	23	24	Yes	Yes	Yes	25+ computers, no air conditioning, temperature complaints-heat
H218	1649	71	25	15	No	Yes	Yes	No airflow, door open, nail polish odor
H220	1052	71	22	3	No	Yes	Yes	
H224	753	70	19	13	Yes	Yes	Yes	
H229	960	71	22	22	Yes	Yes	Yes	
Cafeteria	961	73	24	~350	Yes	Yes	Yes	Doors open
H118	999	73	22	22	Yes	Yes	Yes	

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Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results – Triton Regional Middle/High School, Newbury, MA – February 12, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
H112	588	71	17	13	Yes	Yes	Yes	
H106	1300	72	22	12	Yes	Yes	Yes	
H102	639	71	18	7	Yes	Yes	Yes	
H101	521	71	18	13	Yes	Yes	Yes	Door open
H108	842	69	21	13	Yes	Yes	Yes	Birds-shavings on floor, plants, dry erase board, door open
H110	672	67	21	15	Yes	Yes	Yes	Dry erase board, door open
H113	698	68	27	0	Yes	Yes	Yes	
H112	616	68	21	4	Yes	Yes	Yes	Door open
H117	914	68	23	19	Yes	Yes	Yes	Mercury thermometer
H119	582	69	22	1	Yes	Yes	Yes	Water-damaged sink/sink seam, parrot waste, door open
H116	552	69	20	0	Yes	Yes	Yes	

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Comfort Guidelines

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Indoor Air Test Results – Triton Regional Middle/High School, Newbury, MA – February 12, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Library	564	68	20	1	Yes	Yes	Yes	
Woodshop	747	70	22	15	Yes	Yes	No	
High School Main Office	572	70	20	2	No	Yes	Yes	

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CT = ceiling tiles

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	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%